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(54) **GESTURE AND TOUCH INPUT DETECTION THROUGH FORCE SENSING**

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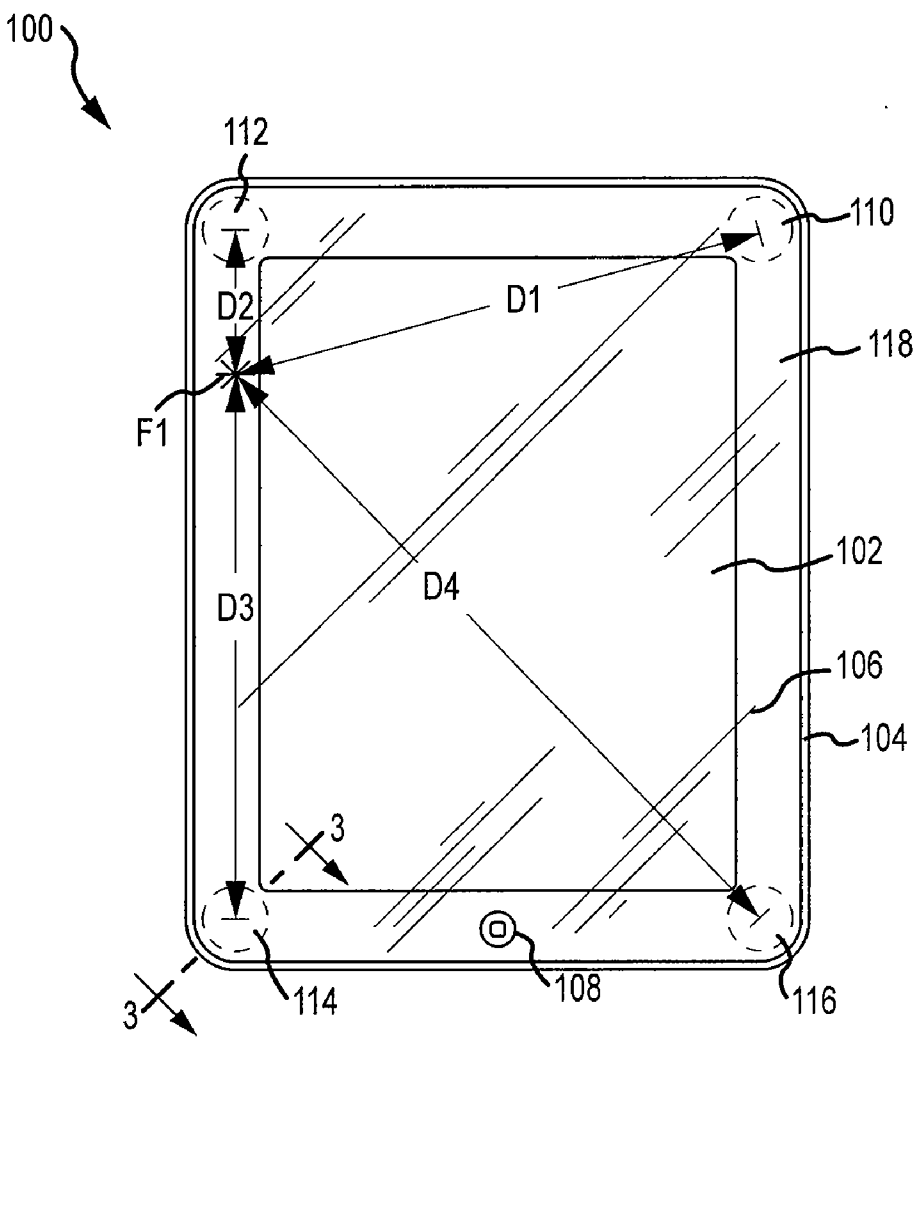
(57) **ABSTRACT**

A computing device configured detect a user input. The computing device includes a processor, a touch interface in communication with the processor and configured to detect a touch signal corresponding to an object approaching or contacting a surface, and at least three force sensors in communication with the processor and configured to detect a force signal corresponding to an object exerting a force on the surface. In response to the force the at least processor determines a force centroid location and the touch signals are processed by the processor by analyzing the force centroid location.



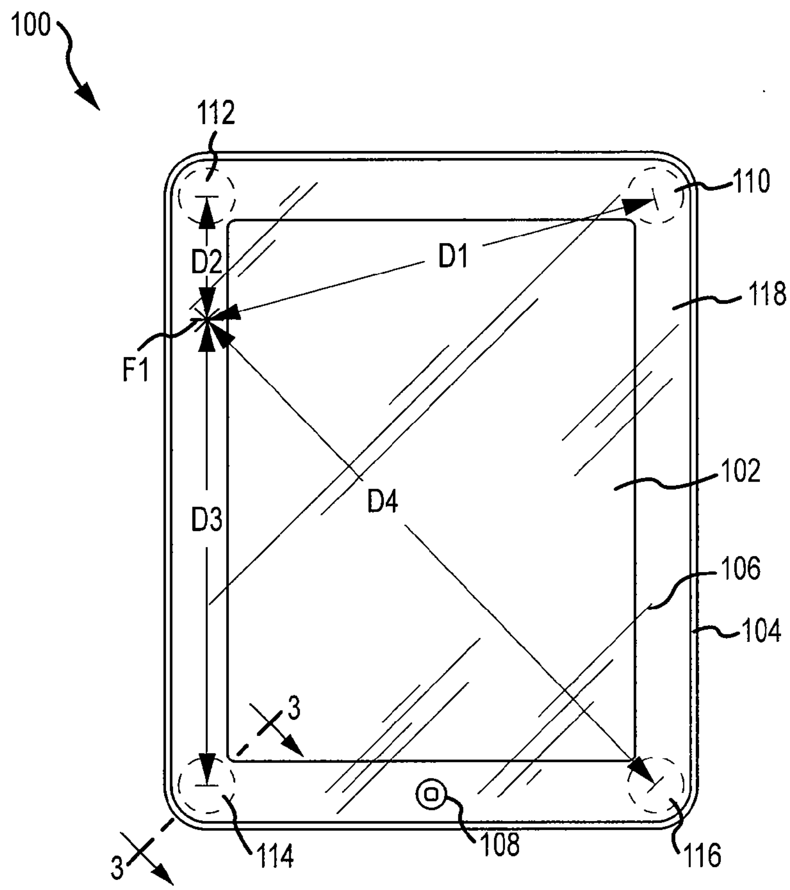


FIG.1

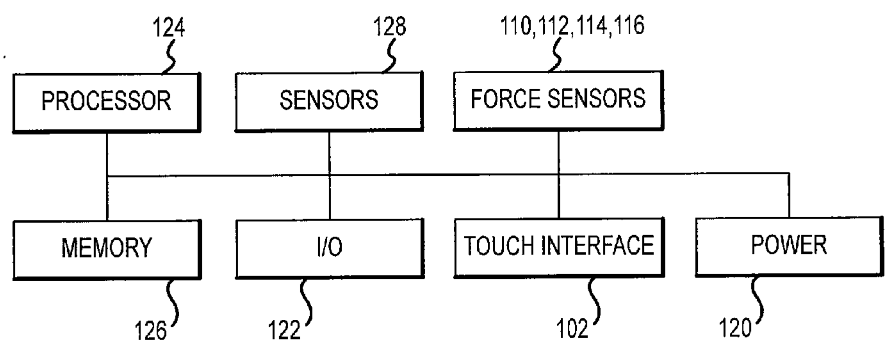

124
128
110,112,114,116
PROCESSOR
SENSORS
FORCE SENSORS
MEMORY
I/O
TOUCH INTERFACE
POWER
126
122
102
120

FIG.2

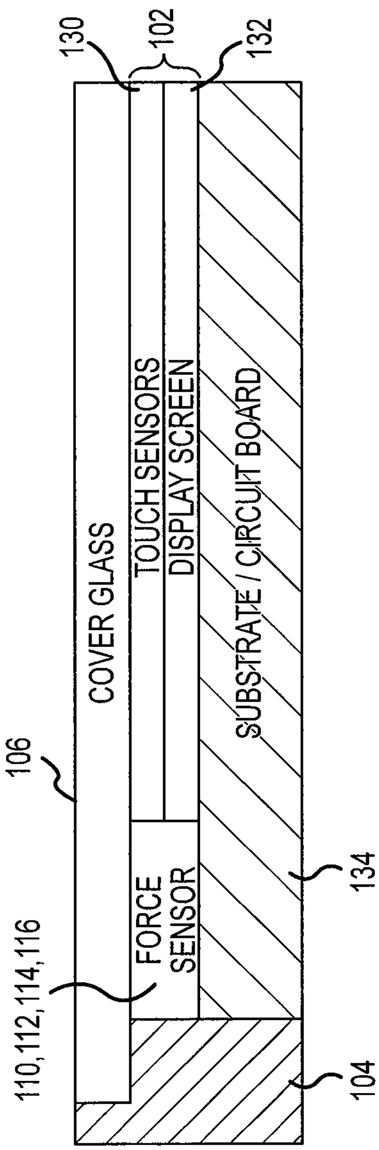

130
102
132
COVER GLASS
TOUCH SENSORS
DISPLAY SCREEN
SUBSTRATE / CIRCUIT BOARD
106
FORCE SENSOR
110,112,114,116
134
104

FIG.3

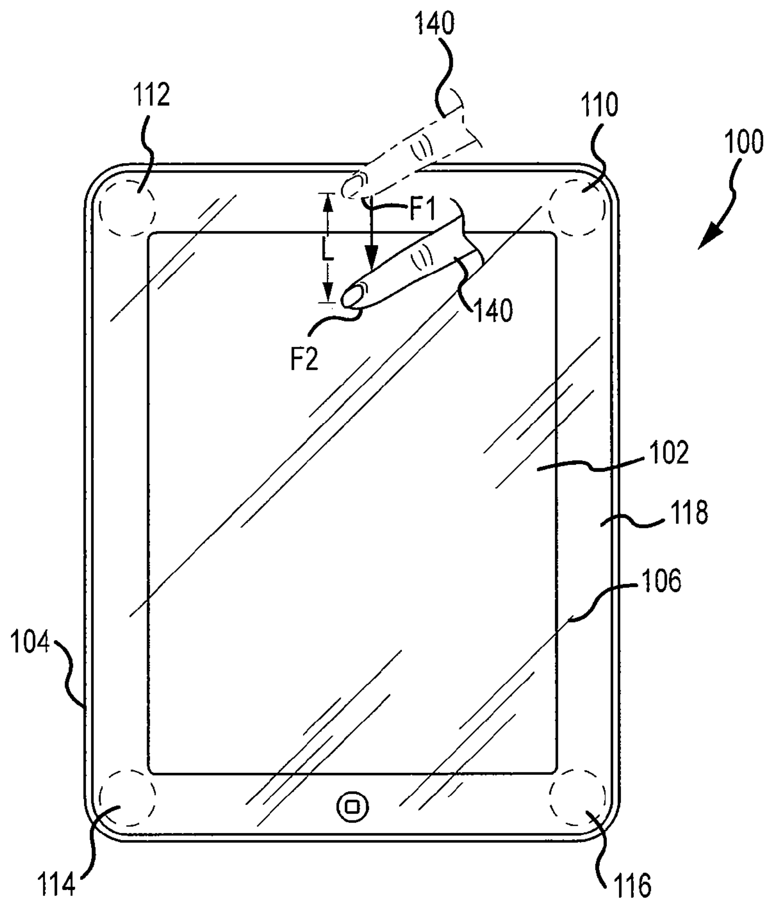


FIG.4A

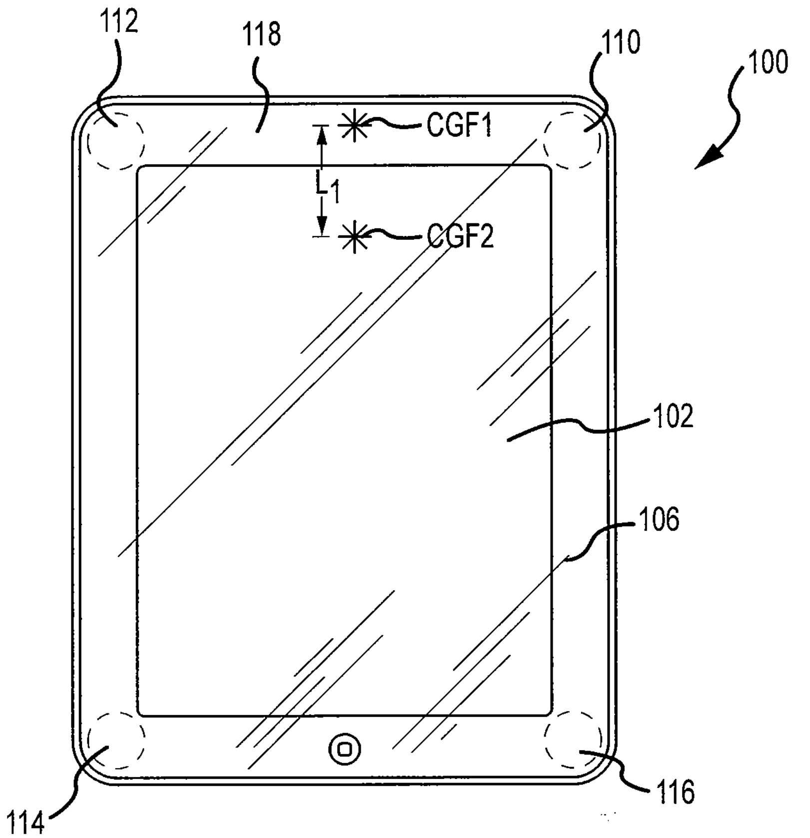


FIG.4B

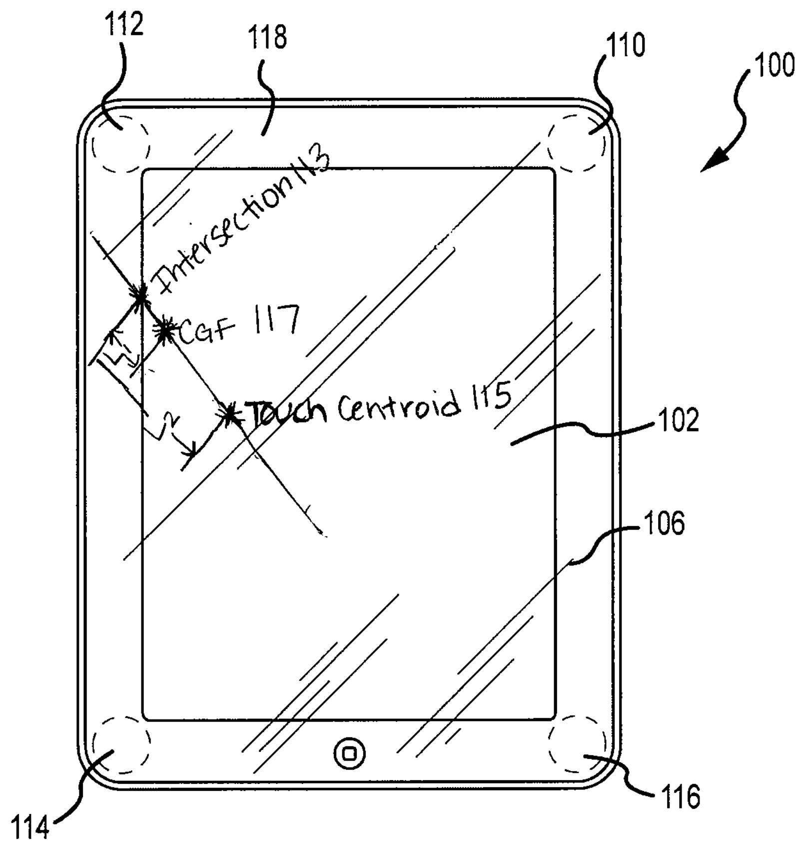

112
118
110
100
Intersection 113
CGF 117
L_1
L_2
Touch Centroid 115
102
106
114
116

FIG. 4C

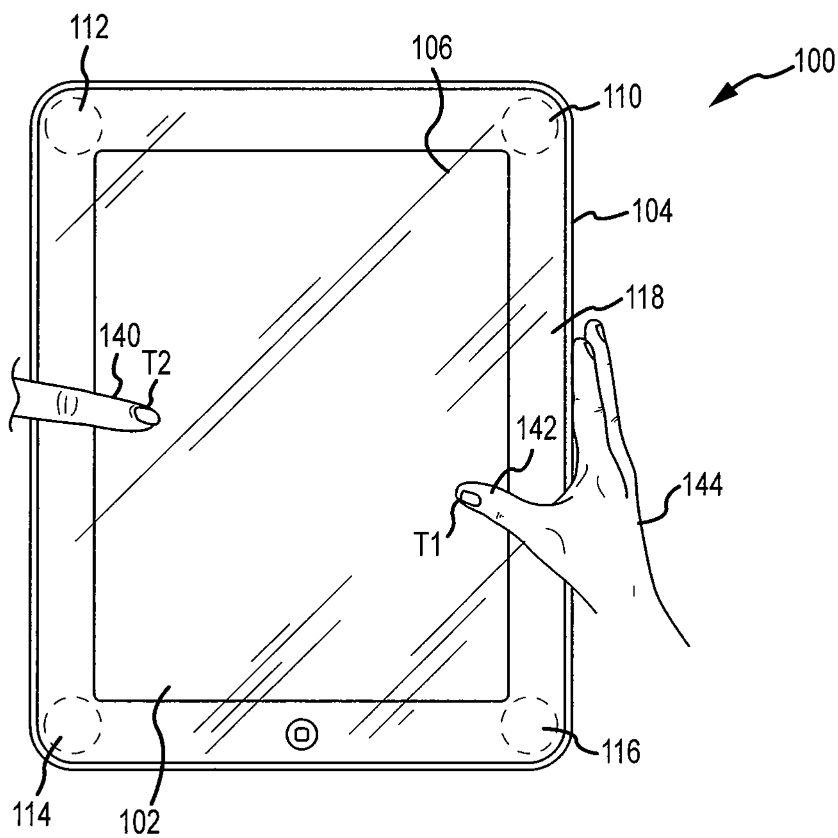


FIG.5A

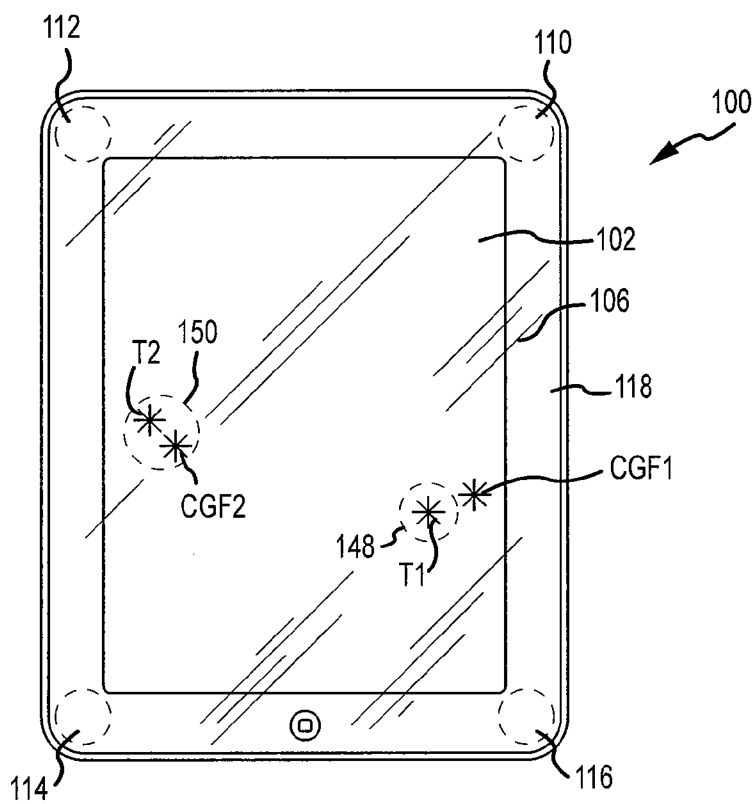


FIG.5B

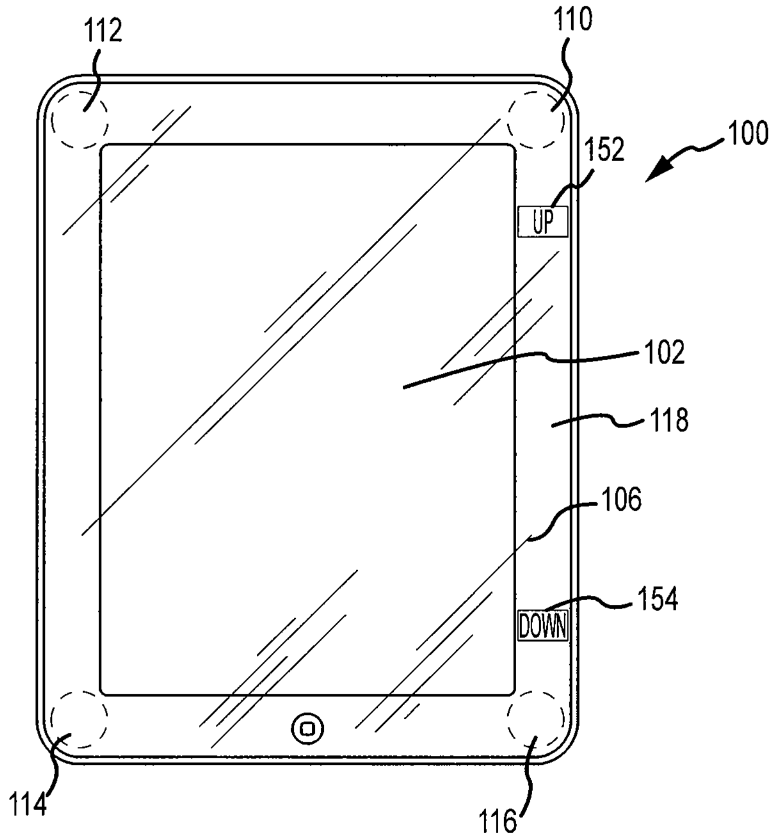


FIG.6

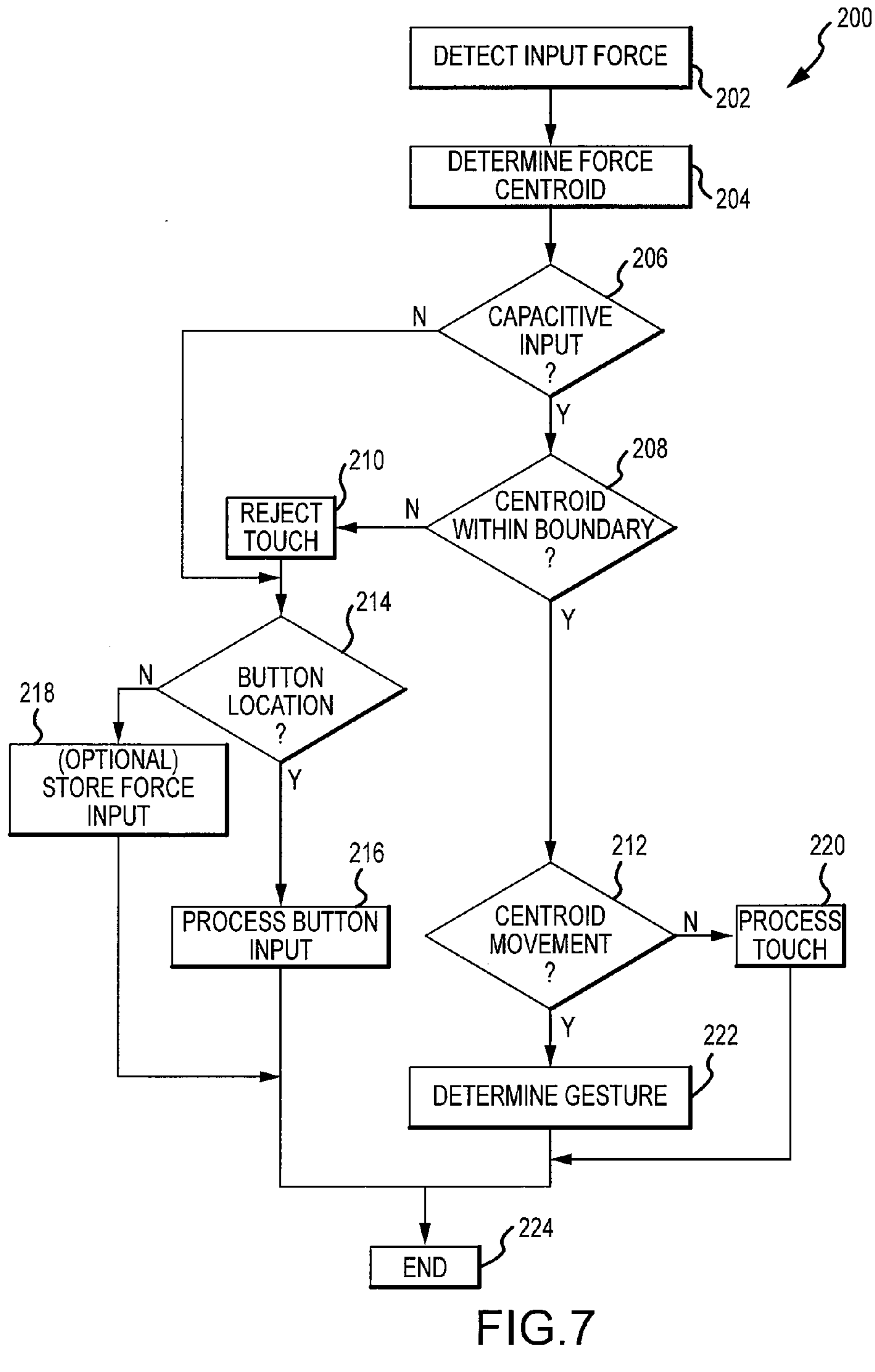

200
DETECT INPUT FORCE
202
DETERMINE FORCE CENTROID
204
206
CAPACITIVE INPUT ?
N
Y
208
CENTROID WITHIN BOUNDARY ?
N
Y
210
REJECT TOUCH
214
BUTTON LOCATION ?
N
Y
218
(OPTIONAL) STORE FORCE INPUT
216
PROCESS BUTTON INPUT
212
CENTROID MOVEMENT ?
N
Y
220
PROCESS TOUCH
222
DETERMINE GESTURE
224
END

FIG.7

GESTURE AND TOUCH INPUT DETECTION THROUGH FORCE SENSING

TECHNICAL FIELD

[0001] The present invention relates generally to computing devices, and more specifically, to detecting inputs for computing devices.

BACKGROUND

[0002] Many types of input devices may be used to provide input to computing devices, such as buttons or keys, mice, trackballs, joysticks, touch screens and the like. Touch screens, in particular, are becoming increasingly popular because of their ease and versatility of operation. Typically touch screens can include a touch sensor panel, which may be a clear panel with a touch-sensitive surface, and a display device that can be positioned behind the panel so that the touch-sensitive surface substantially covers the viewable area of the display device. Touch screens allow a user to provide various types of input to the computing device by touching the touch sensor panel using a finger, stylus, or other object at a location dictated by a user interface being displayed by the display device. In general, touch screens can recognize a touch event and the position of the touch event on the touch sensor panel, and the computing system can then interpret the touch event in accordance with the display appearing at the time of the touch event, and thereafter can perform one or more actions based on the touch event.

[0003] Touch sensor panels can be formed from a matrix of row and column traces, with sensors or pixels present where the rows and columns cross over each other while being separated by a dielectric material. Each row can be driven by a stimulation signal, and touch locations can be identified through changes in the stimulation signal. Typically, a touch location is sensed based on an interference of the stimulation signal, such that a touch location may correspond to a location where the stimulation signal is the weakest. Touch sensor panels may generally be configured to detect touches from a user's fingers, which generally have a surface area that contacts the touch sensor panel to disturb the stimulation signal sufficiently for touch location to be recognized.

[0004] In some instances, computing devices incorporating touch screens may be configured to detect one or more gestures as user inputs. For example, a first type of finger movement, such as a user moving two fingers away from each other may indicate a first type of input (e.g., a zoom-in command), whereas a second type of finger movement, such as a user moving two fingers towards each other may indicate a second type of input (e.g., a zoom-out command). However, in some instances, if a user begins a gesture just outside of the touch screen sensing region, such as towards an edge of the device, the gesture may be difficult to detect because only a portion of the gesture may be detected by the touch screen. In these instances, computing devices may sense inputs that may be different from a user's intended input.

SUMMARY

[0005] One example of the present disclosure may take the form of a computing device configured detect a user input. The computing device includes a processor, a touch interface in communication with the processor and configured to detect a touch signal corresponding to an object approaching or contacting a surface, and at least three force sensors in communication with the processor and configured to detect a force signal corresponding to an object exerting a force on the surface. In response to the force the processor determines a force centroid location and the touch signals are processed by the processor by analyzing the force centroid location.

[0006] Another example of the disclosure may take the form of a method for detecting user inputs to a computing device through force sensing. The method includes detecting by three or more force sensors a force input, calculating by a processor in communication with the force sensors a force centroid based on the force input, and using the force centroid to analyze one or more user inputs to the computing device.

[0007] Yet another example of the disclosure may take the form of a mobile computer configured to detect at least two types of user inputs. The mobile computer includes a processor, a touch screen in communication with the processor, and at least three pressure sensors in communication with the processor. The touch screen is configured to detect a touch signal corresponding to a user finger approaching or contacting the touch screen. The at least three pressure sensors are configured to detect a pressure signal corresponding to an object proving pressure on a surface. In response to the pressure signal the processor determines a centroid location relative to the surface and the touch signal is processed by the processor by analyzing the centroid location.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a top plan view of a computing device including a touch interface for detecting one or more touch inputs.

[0009] FIG. **2** is a simplified block diagram of the computing device of FIG. **1**.

[0010] FIG. **3** is a simplified cross-section view of the computing device taken along line **3-3** in FIG. **1**.

[0011] FIG. **4**A is a top plan view of a user providing an input gesture to the computing device.

[0012] FIG. **4**B is a top plan view of a first force centroid and a second force centroid corresponding to the input gesture of FIG. **4**A.

[0013] FIG. **4**C is a top plan view illustrating a force centroid location and a touch centroid location based on one or more user inputs.

[0014] FIG. **5**A is a top perspective view of the computing device of FIG. **1** being grasped by a user.

[0015] FIG. **5**B is a top plan view illustrating the force centroid locations based on one or more user inputs.

[0016] FIG. **6** is a top plan view of the computing device of FIG. **1** having user input buttons positioned on a non-capacitive touch sensitive surface.

[0017] FIG. **7** is a flow chart illustrating a method for detecting user inputs and touch gestures using force sensors.

SPECIFICATION

Overview

[0018] In some embodiments herein, a computing device including a touch interface for detecting one or more touch inputs and a plurality of force sensors for detecting one or more force inputs is disclosed. The computing device may include at least three, and typically four or more, force sensors that detect a force input on a surface. The force sensors may be distributed along different portions of the computing device, and generally may be operably connected to a cover surface. The cover surface may cover at portion if not all of the touch screen and/or an enclosure, such as a protective glass layer covering the touch screen or other portions of the computing device. The cover surface may extend over the touch screen, as well as other non-touch sensitive portions of the computing device. For example, in some instances the computing device may include a "black mask" portion or other enclosure area of the display that may border a portion, if not all, of the touch screen, but may not be sensitive to capacitive or touch inputs.

[0019] In some embodiments, the force sensors may be used to detect inputs on non-touch sensitive regions of the computing device. For example, if a user applies a force on the black mask, the force sensors may detect the input force and/or its location. Additionally, the force sensors may be used to enhance detection of inputs on the touch sensitive regions of the computing device. In these embodiments, the force sensors may enhance detection of input gestures that may begin on the non-touch sensitive surface, as well as may provide additional input receiving mechanisms which may allow the non-touch sensitive surfaces of the computing device to receive user inputs.

[0020] In some instances, when an input force is received, such as due to a user applying a force on the cover glass, the force sensors may each detect a force signal that may correspond to the input force, but the sensed signal may vary based on the location of each of the force sensors. For example, if the input force is exerted on a top right hand corner of the surface, a first force sensor adjacent the top right corner of the surface may sense a first force value, a second force sensor that may be in a left bottom corner may sense a second force value, and a third force sensor in a left top corner may sense a third value. These three force values may be used to determine a location of a center of the force or force centroid location.

[0021] The force centroid location may be used to analyze one or more touch inputs and/or user force inputs to the computing device. As a first example, the force centroid may be used in conjunction with any detected touch input to determine if a touch input is part of a force gesture that began off of the touch screen sensitive area, such that the touch input may be treated as a touch gesture. As a second example, the force centroid may be used to determine if one or more touch inputs are accidental, such as due to a user holding the computing device and placing a portion of a finger on the touch sensitive screen but not meaning to provide a touch input. As a third example, the force centroid may be used to detect user inputs outside of the touch sensitive area. In this example, the computing device may detect certain user inputs which may be correlated to virtual buttons or commands outside of the touch sensitive or active touch region.

DETAILED DESCRIPTION

[0022] Turning now to the figures, a computing device including a touch screen will now be discussed in more detail. FIG. **1** is a top perspective view of a computing device **100** including a touch interface **102** and force sensors **110**, **112**, **114**, **116**. The computing device **100** may be substantially any type of electronic device including a touch input mechanism, such as the touch interface **102** or other touch screen and associated components. For example, the computing device **100** may be a laptop computer, a tablet computer, a smartphone, a digital music player, portable gaming station, or the like.

[0023] The computing device **100** may include the touch interface **102**, an enclosure **104** at least partially surrounding the touch interface **102**, a cover surface **106** covering at least a portion of the touch interface **102** and/or the enclosure **104**, and/or one or more input buttons **108**. The enclosure **104** encloses one or more components of the computing device **100**, as well as may surround and/or secure a portion of the touch interface **102** to the computing device **100**. The one or more input buttons **108** may provide input functions to the computing device **100**. For example, the input buttons **108** may adjust a volume for the computing device **100**, turn the computing device **100** on or off, or may provide other inputs for the computing device **100**. Further, the computing device **100** may also include one or more receiving ports (not shown). The receiving ports may receive one or more plugs or connectors, such as but not limited to, a universal serial bus (USB) cable, a tip ring sleeve connector, or the like.

[0024] The cover surface **106** may be incorporated as a portion of the touch interface **102** and/or may be a protective surface that protects the touch interface **102** and/or enclosure **104** or portions thereof. In some embodiments, the cover surface **106** may extend over a top surface of the enclosure **104** as well as a top surface of the touch interface **102**. In these embodiments, the cover surface **106** may also act as an enclosure for the components of the computing device **100**. The cover surface **106** may be a material that may allow for one or more electrical properties to be transmitted therethrough. For example, the cover surface **106** may be a glass or plastic. Additionally, in instances where the touch interface **102** may also include a display screen, at least a portion of the cover surface **106** that extends over the touch interface **102** may be clear or partially transparent. Typically the cover surface **106** should be sufficiently thin to allow for sufficient electrode coupling between the touch interface **102** and any external input objects (e.g., fingers, input devices).

[0025] The touch interface **102** may include one or more touch sensors in order to detect one or more touch or capacitive inputs, such as due to a user placing his or her finger close to or on the cover surface **106** and/or touch interface **102**. The touch interface **102** will be discussed in more detail below, but may generally be any type of interface configured to detect changes in capacitance or other electrical parameters that may be correlated to a user input.

[0026] The force sensors **110**, **112**, **114**, **116** are configured to sense an input force, or a change in a sensed force, that may be applied to the cover surface **106**, the enclosure **104**, and/or touch interface **102**. Although the force sensors are discussed herein as receiving an input force that is applied to the cover surface, it should be noted that the force sensors may be operably connected to a variety of different surfaces or elements within the computing device where a user may apply a force. Accordingly, the discussion of any particular embodiments for the force sensors is meant as illustrative only, and not meant as limiting.

[0027] With continued reference to FIG. **1**, in one embodiment, the first force sensor **110** may be positioned in a top right corner of the computing device **100**, the second force sensor **112** may be positioned in a top left corner of the computing device **100**, the third force sensor **114** may be positioned in a bottom left corner, and the fourth force sensor **116** may be positioned in a bottom right corner of the computing device **100**. The force sensors **110**, **112**, **114**, **116** may be operably connected to the cover surface **106** and/or touch interface **102** and may detect one or more input forces exerted on either the touch interface **102** or the cover surface **106**. In a specific example, the force sensors **106** may be strain gages that may produce a signal based on or otherwise corresponding to a bending force applied thereto. As another example, the force sensors may be capacitive sensors that may sense changes in capacitance as pressure is applied to the cover surface **106**. As yet another example, the force sensors may include optical sensors. In this example, a small camera or other imaging capture device may capture images of a known pattern that may be included on the bottom of the cover surface **106** and/or touch interface. As pressure is applied to the cover surface **106**, the pattern may be varied (e.g., certain points may move closer to each other or may deform outwards), and the camera may capture the pattern and any changes thereto. The pattern changes could be translated by the computing device into one or more scaled images that may translate into force measurements.

[0028] In some embodiments, such as shown in FIG. **1**, the force sensors **110**, **112**, **114**, **116** may be spaced apart from one another along the perimeter of the touch interface **102**, such as in each corner of a rectangular shaped enclosure. However, in other embodiments, the force sensors **110**, **112**, **114**, **116** may be positioned adjacent one another, within the touch interface **102**, above or below the touch interface **102**, or the like. Moreover, although only four force sensors are illustrated, the computing device **100** may include substantially any number of force sensors **102**. That said, in many embodiments, the computing device **100** may include at least three force sensors **102** to better estimate the location of a force centroid, which will be discussed in more detail below. Additionally, the number and positioning of the force sensors may be varied based on changes in the shape, dimensions, or the like of the computing device.

[0029] The computing device **100** may include one or more components that may be in communication with one another. FIG. **2** is a simplified block diagram of the computing device **100**. With reference to FIG. **2**, the computing device **100** may further include a power source **102**, an input/output interface **122**, a processor **124**, one or more memory components **126**, and/or one or more sensors **128**.

[0030] The processor **124** may be substantially any electronic device cable of processing, receiving, and/or transmitting instructions. For example, the processor **124** may be a microprocessor or a microcomputer. As described herein, the term "processor" is meant to encompass a single processor or processing unit, multiple processors, or multiple processing units, or other suitably configured computing element. For example, select components of the electronic device **100** may be controlled by a first processor and other components of the electronic device **100** may be controlled by a second processor, where the first and second processors may or may not be in communication with each other. As a specific example, the touch interface **102** may include one or more separate processing components that may be in communication with the processor **124**.

[0031] The memory **126** may store electronic data that may be utilized by the electronic device **100**. For example, the memory **126** may store electrical data or content e.g., audio files, video files, document files, and so on, corresponding to various applications. The memory **126** may be, for example, non-volatile storage, a magnetic storage medium, optical storage medium, magneto-optical storage medium, read only memory, random access memory, erasable programmable memory, flash memory, or a combination of one or more types of memory components.

[0032] The electronic device **100** may also include one or more sensors **128**, in addition to the force sensors **110**, **112**, **114**, **116** and/or touch sensors incorporated into the touch interface **102**. The sensors **128** may provide substantially any type of input to the electronic device **100**. For example, the sensors **128** may be one or more accelerometers, gyroscopes, light sensors, image sensors (such as a camera), force sensors, and so on.

[0033] The power source **120** may be substantially any device capable of providing energy to the computing device **100**. For example, the power source **120** may be a battery, a connection cable that may be configured to connect the computing device **100** to another power source such as a wall outlet, or the like.

[0034] The input/output interface **122** may be configured to provide communication to and from the computing device **100**. For example, the input/output interface **122** may facilitate communication by the computing device to and from a variety of devices/sources. For example, the input/output interface **122** may receive data from user, control buttons on the computing device **100**, and so on. Additionally, the input/output interface **122** may also receive/transmit data to and from an external drive, e.g., a universal serial bus (USB), or other video/audio/data inputs.

[0035] It should be noted that FIGS. **1** and **2** are exemplary only. In other examples, the electronic device may include fewer or more components than those shown in FIGS. **1** and **2**. Additionally, the illustrated electronic device is only an example of a computing device incorporating the touch interface and force sensors.

[0036] The touch interface **102** and force sensors **110**, **112**, **114**, **116** will now be discussed in more detail. FIG. **3** is a cross-section view of the computing device **100** taken along line **3-3** in FIG. **1**. With reference to FIG. **3**, the cover surface **106** may extend over a top surface of the enclosure **104**, as well as over the force sensors **110**, **112**, **114**, **116**, and the touch interface **102**. The force sensors **110**, **112**, **114**, **116** may be operably connected to the cover surface **106**, the enclosure **104**, as well may be in communication with the touch interface **102**.

[0037] With reference to FIG. **3**, the touch interface **102** and/or force sensors **110**, **112**, **114**, **116** may be operably connected to and/or in communication with a substrate or circuit board **134**. The substrate **134** may provide communication between the force sensors **110**, **112**, **114**, **116** and/or touch interface **102** with one or more components for the computing device **100**, such as but not limited to, the processor **124**, the memory **126**, and the power source **120**.

[0038] The touch interface **102** is configured to receive inputs from an object (e.g., location information based on a user's finger or data from the input device) and to send this information to the processor **124**. The touch interface **102** may report touches to the processor **124** and the processor interprets the touches in accordance with its programming. For example, the processor may initiate a task in accordance with a particular touch. The touch interface **102** may include a display screen **132** and a sensor panel **130** positioned at least partially over the display screen **132**.

[0039] The display screen **132** is configured to display one or more output images and/or videos for the computing device **100**. The display screen **132** may be substantially any type of display mechanism, such as a liquid crystal display (LCD), plasma display, or the like. In instances where the display screen **132** is a LCD display, the display screen **132** may include (not shown) various layers such a fluorescent panel, one or more polarizing filters, a layer of liquid crystal cells, a color filter, or the like. It should be noted that FIG. **3** is not drawn to scale and is a schematic view of the touch interface **102**, for instance, there may be a gap (not shown) between on or more components of the touch interface and/or cover surface.

[0040] In some embodiments, the cover surface **106** may be a clear glass or plastic panel that may allow the display screen **132** to be viewable therethrough. The sensor panel **130** may include one or more electrodes which may be deposited on the cover surface **106**. For example, the electrode layer may include transparent conductive materials and pattern techniques such as ITO and printing.

[0041] It should be noted that in some embodiments, the touch interface **102** be substantially any type of touch screen or touch detecting component(s). For example, the touch interface may not be see-through and/or may not correspond to a display screen. In these instances, a particular surface or group of surfaces may be configured to receive touch inputs, that may or may not correspond to a separately displayed user interface, icons, or the like.

[0042] The sensor panel **130** may include one or more touch sensors that may detect changes in an electrical parameter that may correspond to an object touch or approaching the touch interface **102**. For example, the sensor panel **130** may include one or two layers of electrodes which may be spaced apart across the panel **130**. The electrodes may define one or more nodes that act as capacitive coupling sensors to detect touches on the touch interface **102**. The number and configuration of the nodes may be varied, depending on the desired sensitivity of the touch interface **102**.

[0043] In some embodiments, the sensor panel **130** of the touch interface **102** may be configured to detect touches on the surface of the touch interface **102** by sensing one or more changes in capacitance. Typically when two electrically conductive members come close to one another, without actually touching, their electric fields interact to form a capacitance. As briefly described above, the sensor panel **130** may include a plurality of sensing nodes that may be formed by one or more electrodes that may interact with an external object, such as a user's finger, to detect the presence of the object.

[0044] The touch interface **102** can detect changes in capacitance at each node, which may allow the touch interface **102** to determine when and where a user has touched various surfaces of the cover surface **106** and/or touch interface **102** with one or more objects. The touch interface **102** may be substantially any type of touch detecting mechanism as generally known in the art, and the specific implementations may be based on a number of different factors, such as but not limited to, the size of the touch screen, the desired sensitivity of the touch screen, and so on. Accordingly, the discussion of the any particular touch interface configuration is meant as illustrative only and not limiting.

[0045] With reference again to FIG. **3**, the force sensors **110**, **112**, **114**, **116** may be operably connected to the cover surface **106** in order to detect input forces that may be applied at substantially any location of the cover surface **106**. For example, the force sensors **110**, **112**, **114**, **116** may measure force by sensing a deflection of the cover surface **106**. However, in other embodiments, the force sensors **110**, **112**, **114**, **116** may be other mechanisms configured to sense a change in one or more parameters that may be correlated to a change in force.

[0046] The touch interface **102** and the force sensors **110**, **112**, **114**, **116** may be used to determine the location and strength of various inputs to the cover surface **106** of the computing device **100**. The computing device **100**, using the force sensors **110**, **112**, **114**, **116** positioned at each corner of cover surface **106**, may be configured to determine the location of a force centroid for a user input or inputs. The force sensors may be differently configured and/or positioned in other embodiments, but may still be used to determine and assign forces to particular input locations.

Centroid Calculations with a Detected Touch Position

[0047] For user inputs that are in communication with the touch interface **102** (e.g., detectable by the touch interface, such as being within an active touch region), the touch sensors **130** may determine the location of any touches or inputs to cover surface **106** positioned over the touch interface **102**, and the force sensors **110**, **112**, **114**, **116** may determine the force magnitude at locations of the cover surface **106**.

[0048] For example, in instances where the user provides an input force to the cover surface **106** above the touch interface **102** with a single finger, the computing device **100** may associate that position with the entire force detected by the one or more force sensors **110**, **112**, **114**, **116**. However, in many instances the user may provide an input force or forces with one or more fingers and/or other portions of his or her hand. For example, the touch interface **102** may be used to capture input gestures based on the number or type of finger inputs. In these instances, the computing device **100** may determine an input force associated with several or all of the various touch locations on the cover surface **106** to input force levels. In some embodiments, the computing device **100** may determine a centroid of the overall applied force, which may include a location of approximately a center of the applied forces. In this manner, if there is a force applied by two fingers of a user, the centroid may be positioned between the two fingers.

[0049] Examples of centroid calculations to determine the force centroid location will be discussed in more detail below. As briefly discussed above, in instances where the input force may be applied to the touch interface **102**, the position of the force may be determined based on the touch location data sensed by the touch interface **102**. In these embodiments, the computing device **100** may determine the touch location providing a majority of the input force using a centroid calculation. However, because in some embodiments the computing device **100** may include only a four force sensors **110**, **112**, **114**, **116**, some calculations and/or estimations may be used to determine the finger that may be providing the input force. As described in more detail below, the computing device **100** may utilize the position information as detected by touch interface **102** along with various force signals detected by the four force sensors **110**, **112**, **114**, **116** to determine the touch location corresponding to a particular force. By determining the centroid of the input forces provided to the cover surface **106**, and due to the position of touches on the cover surface **106** detected by the sensor panel **130** of the touch screen **106**, the computing device **100** may determine the finger providing the input force as the finger closest to the force centroid. The global force centroid C_{GF} may be expressed by Eq. (1) below:

$$C_{GF} = \frac{\sum W_i P_i}{\sum W_i} \quad \text{Eq. (1)}$$

[0050] In Eq. (1), the global force centroid C_{GF} is expressed as the sum of a select number of positions Pi multiplied times the weight Wi at each position Pi, divided by the sum of the weights Wi. The positions Pi may be determined by the touch interface **102**. For example, if the user presses on the cover surface **106** with two fingers, those fingers may provide a position input signal (such as a change in capacitance) at two separate locations or nodes. Those locations may be used as two input positions Pi in Eq. (1). In some instances, the positions Pi may a set or coordinates or a single axis coordinates, in the latter example, Eq. (1) may be repeated twice, once for a X or horizontal axis and once for a Y or vertical axis. In other examples, such as illustrated in Eq. (2), the positions Pi may be represented as position vectors relative to a predetermined origin. The weight Wi may be same as the force sensed by each force sensor, or may be the force sensed by each force sensor multiplied by gravitational acceleration (e.g., 9.80665 m/s^2 or 32.174 ft/s^2).

[0051] Eq. (1) also uses the weight Wi for each position; however, because there may not be force sensors **110**, **112**, **114**, **116** at every location of the cover surface **106** where there may be a touch, the weight Wi at each position may not be known, only the force at the location of the force sensors **110**, **112**, **114**, **116**. In these embodiments, the position information along with the force sensed at each input sensor **110**, **112**, **114**, **116** may be used to solve for a global force centroid.

[0052] Using the example of a computing device **100** having four force sensors **110**, **112**, **114**, **116**, Eq. (1) may be expanded to include the values for each of the input sensors **110**, **112**, **114**, **116** extrapolated to Eq. (2) below:

$$\vec{C}_{GF} = \frac{LPF(C_{BL}^{F[n]})x\vec{C}_{BL}^{position} + LPF(C_{TL}^{F[n]})x\vec{C}_{TL}^{position} + LPF(C_{RL}^{F[n]})x\vec{C}_{RL}^{position} + LPF(C_{RB}^{F[n]})x\vec{C}_{RB}^{position}}{LPF(C_{RL}^{F[n]}) + LPF(C_{TL}^{F[n]}) + LPF(C_{RL}^{F[n]}) + LPF(C_{RB}^{F[n]})} \quad \text{Eq. (2)}$$

[0053] In Eq. (2) above and with reference to FIG. **1**, LPF represents the low pass filter, $C_{RB}{}^{F[n]}$ is the force registered by the right bottom (RB) force sensor **116**, $\vec{C}_{BL}{}^{position}$ is the position vector from respective sensor to the touch position, $C_{TL}{}^{F[n]}$ represents the force registered by the top left force sensor **110**, $\vec{C}_{TL}{}^{position}$ is the position vector from respective sensor to the touch position, $C_{RL}{}^{F[n]}$ is the force registered by the right top force sensor **112**, $\vec{C}_{RL}{}^{position}$ is the position vector from respective sensor to the touch position, $C_{RB}{}^{F[n]}$ is the force registered by the right bottom force sensor **114**, $\vec{C}_{RB}{}^{position}$ is the position vector from respective sensor to the touch position, which may represent the location and value of particular force relative to a particular predetermined origin.

[0054] As indicated in Eq. (2) in some embodiments, the values for the force sensors may be low pass filtered prior to processing. This filtering may be used to remove noise, such as spikes within the signal. However, in other instances, the input values from the force sensors **110**, **112**, **114**, **116** may not need to be low pass filtered based on the noise level for each of the signals. As described above, the force sensors **110**, **112**, **114**, **116** may be configured to detect a force at a predetermined location. However, in instances where there may be one or more forces applied to the cover surface **106**, the force registered at each force sensor **110**, **112**, **114**, **116** may be reduced or increased as compared to other sensors **110**, **112**, **114**, **116** based on the distance of the applied force from the respective force sensor **110**, **112**, **114**, **116**. In other words, a moment of the cover surface **106** for a particular force sensor **110**, **112**, **114**, **116** may vary based on distance from the particular force as a moment arm or perpendicular distance from the force location to the force sensor **110**, **112**, **114**, **116** may increase or decrease. In some embodiments, the force sensors **110**, **112**, **114**, **116** may be strain gages, which may register varying force inputs based on the moment, so that the force inputs as sensed by the force sensors **110**, **112**, **114**, **116** may vary based on the distance to a respective input force.

[0055] Although the above examples were described with respect to four force sensors **110**, **112**, **114**, **116**, in other embodiments, three sensors or more than four sensors may also be used. For example, because only three points are required to define a plane, the computing device **100** may include only three force sensors and use substantially the same calculations as above. Alternatively, the computing device **100** may include more force sensors in order to refine the above calculations.

[0056] Using Eq. (2) above, the global force centroid, that is the location of the center of the applied force, may be determined. As an example, with a single touch, the center of the force may be determined by analyzing the force registered at each force sensor, along with the location of the touch detected by the touch interface **102**. Because is this example, there is only a single input touch, the computing device **100** may determine that the entire force was provided at the location of the force centroid, and then use that knowledge to determine the force magnitude applied thereto.

Centroid Calculations without a Detected Touch Position

[0057] For user inputs that are not in communication with the touch interface **102**, such as those that are in the black mask **118** portion of the cover surface **106** that is not above the touch interface **102**, or otherwise outside of the touch sensitive region of the touch screen, the force sensors **110**, **112**, **116**, **118** may detect the force magnitude and may extrapolate position from the varying values detected by each sensor **110**, **112**, **114**, **116**. For example, with reference to FIG. **1**, assuming that a first force F**1** is applied to a portion of the cover surface **106** outside of the touch sensitive region, each of the sensors **110**, **112**, **114**, **116** may sense a different force value (although the total applied input force may be constant) that may correspond to the distance that each force sensor **110**, **112**, **114**, **116** is positioned from the input force F**1**. As shown in FIG. **1**, the first force sensor **110** may be spaced a distance of D**1** from the input force F**1**, the second force sensor **112** may be spaced a distance of D**2** from the input force F**1**, the third force sensor **114** may be spaced a distance of D**3** from the input force F**1**, and the fourth force sensor **116** may be spaced a distance of D**4** from the input force F**1**.

[0058] In the example illustrated in FIG. **1**, the input force F**1** is shown closest to the second sensor **112**, and thus the second force sensor **112** may sense the largest magnitude force. Similarly, the third force sensor **114** may sense the second largest magnitude force, and so on. In this example, the differences in sensed force magnitude may correspond to the difference in distance that each of the force sensors **110**, **112**, **114**, **116** are positioned from the input force F**1**. Because the distance from which each of the sensors **110**, **112**, **1146**, **116** are positioned from each other is known, this known distance may be used along with the varying sensed magnitudes to determine the approximate location of the input force F**1**.

[0059] As a specific, non-limiting example, the centroid location may be determined by determining the location of an axis centroid along a first axis and a second axis. The axis centroid values may then represent a coordinate for the overall centroid location. In this example, the computing device may use force values as measured by each of the sensors **110**, **112**, **114**, **116** on a given axis of the device **100** (e.g., x or y axis). In some instances the device may include an axis centroid value for each side of the device, e.g., a left y axis, a right y axis, a top x axis, and/or a bottom x axis. Each value for a particular axis may be summed, and then value as detected by each respective sensor (that is, the force sensed by each sensor) may be multiplied by that axis length, providing a location of the axis centroid with respect to the particular axis. Specifically, if the second sensor **112** senses a force of 80 grams and the fourth sensor **114** senses a force of 20 grams, the total force for the left y axis may be 100 grams. In instances where the distance between the second sensor **112** and the fourth sensor **114** is 160 mm, than the force centroid for this example on the left edge y axis may be (80 g/100 g)*160 mm, such that the centroid for this axis is 128 mm from the fourth sensor **114** and 32 mm away from the second sensor **112**. However, it should be noted that the above example is only one manner in which the force centroid may be determined, and other embodiments are envisioned. Moreover, the calculations for a force centroid may be varied based on the number and/or position of the sensors.

Using the Force Centroid Location

[0060] Using the equations listed above, the location of the global force centroid C_{GF} can be determined for both instances where a touch may be detected by the touch interface **102**, as well as instances where a touch may not be detected by the touch interface **102**. The computing device **100** may then use the location of the C_{GF} to track changes in applied force in order to better detect gestures that may begin in the black mask **118**. FIG. **4**A is a top plan view of a user's finger **140** providing a first force F**1**, the moving across the cover surface **106** to provide a second force F**2**. It should be noted that the two forces F**1** and F**2** may be a substantially continuous force applied along a length L1 of the movement of the finger **140**, but may indicate the beginning and the end of a user input, such as a gesture.

[0061] After the user has input the finger gesture, by moving his or her finger **140** from the black mask **118** towards the touch interface **102**, the location of the force centroid may also move. FIG. **4**B is a top plan view of the computing device **100** of FIG. **4**A illustrating a first force centroid C_{GF1} and a second force centroid C_{GF2} corresponding to the first force F**1** and the second force F**2**, respectively. The two force centroid C_{GF1} and C_{GF2} may be determined using the equations above, and as the finger moves **140**, and the force location moves, the global force centroid (that is, the center of the applied forces) may correspondingly move. In this manner the computing device **100** may be able to determine that the finger **140** moved from the black mask **118** towards the touch interface **102**, although the touch interface **102** may not detect a first touch corresponding to the first force, but only a second touch corresponding to the second force F**2**. In this example, when the touch interface **102** finally detects the touch the processor may be able to determine whether a corresponding force centroid originated in the black mask **118** (or other portion outside of the touch interface **102**) and is now at or close to the second finger. That is, whether the force centroid moved a distance of L1 that may be correlated to a distance from the second touch position to the black mask **118**.

[0062] In the example illustrated in FIGS. **4**A and **4**B, the force sensors **110**, **112**, **114**, **116** may sense different values for approximately the same level of force based on the distance between the force and a particular force sensor. In other words, for the first force F**1**, the force sensors **110**, **112** positioned at the top of the cover surface **106** may sense a larger force magnitude as compared to the bottom force sensors **114**, **116**. In this manner, the processor may use the above provided equations to estimate the force centroid by approximating the location of the touch or by correlating the position of the force based on the different magnitudes detected at each force sensor **110**, **112**, **114**, **116**. An estimate of the location of the force centroid may be sufficient to determine if a user provide input is a gesture and/or whether it began in the black mask **118** because more detailed inputs of the gesture may be detected by the touch interface **102** once they extend across the black mask **118**.

[0063] In some embodiments, the computing device **100** may determine or estimate a force applied to the black mask or non-touch sensitive portion of the cover surface. FIG. **4**C is a top plan view illustrating a touch location centroid and force centroid. With reference to FIG. **4**C, the processor may analyze the force centroid in light of a touch centroid location to determine what percentage of the total force sensed by the force sensors **110**, **112**, **114**, **116** may be attributed to touches on the touch interface **102** as opposed to touches on the black mask **118**. The touch location centroid **115** may be the centroid of one or more touches as sensed by the touch interfaces. In other words, if there is a single touch on the touch interface, the touch centroid will be positioned at that touch location, and if there is more than one touch, the touch centroid may be positioned at the centroid between the touches. The force centroid **117**, as discussed in more detail above, may be positioned at the centroid of the sensed forces applied to the cover surface. The force allocation between the touch interface **102** and the black mask **118** may be used to provide inputs to the device **100**, as well as help to evaluate touches as discussed in more detail below.

[0064] With reference to FIG. **4**C, in instances where the force centroid C_{GF} **117** does not match a computed touch location centroid **115**, the processor may determine that the discrepancy may be due to the fact that a touch was applied in the black mask **118** region. Such a touch likely would not be detected by the touch interface **102**, as it falls outside the touch sensitive region. In other words, if a user provides a force in the black mask, the force sensors may detect the applied force, but the touch interface may not detect the touch location, and thus the touch location would not be incorporated into the touch location centroid. Accordingly, in these instances, the force centroid may be a first position and the touch location centroid **115** may be at a second location, spaced apart from the force centroid **117** location.

[0065] Using these assumptions, the device **100** may determine the intensity of a force applied in the black mask **118**. Specifically, the location difference between the touch centroid and the force centroid may be used to determine (or at least estimate) the location and intensity of a force applied in the black mask **118** region. For example, the computing device **100** may take into account the known location of the black mask **118**, shown in FIG. **4**C as being a rectangle surrounding the touch interface **102**. In this example, a line extending from the touch centroid location, through the force centroid, and through the black mask **118** boundary region may be determined. That is, the two centroids may be connected through a line extending between the two, and the line may extend towards the black mask **118** bordering the touch sensitive region.

[0066] The intersection point **113** of the line as it enters the black mask region **118** may be used as a likely indicator of the location of the force input on the black mask **118**. This may allow the computing device **100** to determine the side of the black mask **118** where the force was applied, as well as a general estimate of the actual location relative to that side of the black mask. Once the intersection **113** location is known, the ratio of the distance between the force centroid and the touch centroid to that location may be used to estimate the percentage of force applied in the touch region versus the black mask region. For instance, the force centroid may be located at a distance L**2** from the intersection point and the touch location centroid may be located at a distance L**1** from the intersection point. The percentage of the total sensed force that may be attributed to the black mask **118** region may be determined to be equal to one minus the ratio of the distance L**2** over the distance L**1**. Expressed as an equation

$$\text{BlackMaskForce }\%=(1-L2/L1)\times 100.$$

[0067] The remaining percentage of the sensed force may then be attributed to the touch interface touch locations. In this manner, the percentage of the total force applied to the cover surface **106** that was applied in the black mask region **118**, as well as the percentage applied in the touch interface **102** region may be determined.

[0068] The force sensors **110**, **112**, **114**, **116** may also be used to determine whether a user force should be rejected or ignored. In other words, whether a user input on the touch interface **102** may be accidental. FIG. **5**A is a top perspective view of a user holding the computing device **100** with one hand **144** and applying a force with a finger **140** from a second hand. FIG. **5**B illustrates the force centroid location due to a touch by a thumb **142**. With reference to FIGS. **5**A and **5**B, in some embodiments, users may hold the computing device **100** with one hand **144** while using the second hand to provide touch inputs to the touch interface **102**. In some instances, one or more fingers of the first hand **144**, such as the thumb **142** illustrated in FIG. **5**A, may extend across the black mask **118** onto the touch interface **102**. The placement of the thumb **142** (or other finger) may cause the touch interface **102** to detect a user touch input, although the user may have inadvertently placed the thumb **142** on the touch interface **102**. In other words, although the user may have touched the thumb **142** on the touch interface **102**, he or she may not have wished to provide a touch input to the device **100**.

[0069] With reference to FIG. **5**A, the thumb **142** may input a first touch T**1** and if the user also uses his or her finger **140** from the second hand, that may be a second touch input T**2**. As a first example, in instances where the user may only touch the touch interface **102** with the thumb **142**, the force sensors **110**, **112**, **114**, **116** may detect a force corresponding only to the first touch T**1**, as well as any additional forces exerted on the black mask **118** due to the other portions of the hand **144**. In this example, the force centroid C_{GF1} may be located on the black mask **118** or adjacent to the black mask **118** on the touch interface **102**. In other words, because the hand **144** may also apply some force to the cover surface **106** (as it grips the device **100**), the force centroid may be positioned at a location between the first touch T**1** of the thumb **142** and the position of the hand **144**. In this example, the processor may determine that the first touch T**1** is inadvertent, as the force centroid is not located at the touch position T**1**, but closer towards or on the black mask **118** portion of the cover surface **106**. Thus, using the location of the centroid C_{GF1} the processor may determine that the touch T**1** is inadvertent, as most of the force is centered away from the touch towards or on the black mask **118**.

[0070] In one embodiment, with reference to FIG. **5**B, the computing device **100** may set a boundary **148** around the touch T**1** and if the force centroid C_{GF1} is not within the boundary **148**, the touch T**1** may be rejected and not processed as an input. In these embodiments, the boundary **148** may be set to be wider for touches closer towards a center of the touch interface **102** and may be smaller for touches closer to the black mask **118** or the edge of the touch interface **102**. This may provide a greater sensitivity of the device **100** to reject touch inputs that may be accidental.

[0071] As a second example, with reference again to FIGS. **5**A and **5**B, in some instances, the user may provide a second touch T**2** with the finger **140** from a second hand. In this example, in instances where the second touch T**2** may purposeful, the force centroid may move towards the second touch as the user may apply a stronger force than the resting force of the thumb **142**. Specifically, C_{GF2} may represent the location of the second force centroid that may correspond to the average center of the forces applied by the finger **140** and the thumb **142**. In this case, because the second force centroid C_{GFs} may be located approximately adjacent the second touch T**2** within the second boundary **150** and outside of the boundary **148** around the first touch T**1**, the first touch T**1** may be rejected.

[0072] It should be noted that in some instances a user may provide a purposeful input with both the finger **140** and the thumb **142** (or a second finger). In these instances, the force centroid may be positioned outside of the two boundaries **148**, **150** and thus the processor **124** may interpret both touches as purposeful. This is because the total magnitude of the input forces may be relatively evenly distributed between both the finger **140** and the thumb **142** which may indicate that the user was applying a relatively equal force by both the finger **140** and thumb **142**, and thus meant to provide an input to the touch interface **102** with both.

[0073] In some instances, the computing device **100** may include one or more buttons within the black mask **118** or other non-touch sensitive portions of the cover surface **106**. FIG. **6** is a top plan view of the computing device **100** including two buttons **152**, **154** positioned on the black mask **118** outside of the touch sensitive region. In this example, a first button **152** may correspond to a first command and a second button **154** may correspond to a second command. For example, the first button **152** may correspond to a next page command and the second button **154** may correspond to a previous page command. The buttons may be differently configured based on the computing device **100** and/or applications operating on the computing device **100**.

[0074] In the embodiment illustrated in FIG. **6** the buttons may be virtual in that they may not include a mechanical switch, but may be selected based on the location of the force centroid. In other words, a specific button **152**, **154** may be determined to be selected by a user if the force centroid is closer towards a particular button.

[0075] Similarly, the computing device **100** may use the force sensors **110**, **112**, **114**, **116** to detect taps on the black mask **118**. The taps, such as a user pressing on the black mask **118** with his or her finger, may be used as an input to the computing device **100**. For example, a first tap may represent a first command, whereas two taps successively may represent a second command. Additionally, the computing device **100** may detect gestures by a user outside of the touch sensitive region. For example, as a user slides his or her finger along a portion of the black mask **118** the force centroid may move correspondingly, and this motion may be sensed by the force sensors **110**, **112**, **114**, **116** and tracked as a change in the location of the force centroid, and provided as a particular input. In this example, the sliding gesture may be used to switch pages on a reading application, adjust a volume, adjust brightness, and so on. Additionally, in these embodiments, these type of gestures may be distinguished from gestures that ultimately terminate in the touch sensitive region, as these type of gestures may not be correlated to any touch inputs. That is, gestures in the non-touch region, such as the black mask **118**, may not include a corresponding touch input on the touch interface **102**.

[0076] A method for using the force sensors **110**, **112**, **114**, **116** to detect one or more force inputs to the computing device **100** will now be discussed. FIG. **7** is a flow chart illustrating an method **200** for using the force sensors of the computing device **100**. The method **200** may begin with operation **202** and the force sensors **110**, **112**, **114**, **116** may detect an input force. For example, as the user presses against the cover surface **106**, an input force may be detected by the force sensors **110**, **112**, **114**, **116**.

[0077] Once the input force is detected, the method may proceed to operation **204** and the processor **124** may determine the location of the force centroid for the applied force of forces. In some embodiments, the sensed inputs for each of the force sensors **110**, **112**, **114**, **116** may be used to determine the force centroid location. In instances where the input force may be applied to a touch sensitive region, the position of the input forces may be determined by the touch interface **102**, and using the position information and force information the force centroid may be determined. However, for input forces not on the touch sensitive region, the sensed magnitudes by each of the force sensors **110**, **112**, **114**, **116** may be used to determine the location of the force centroid.

[0078] As, during, or after the force centroid is determined, the method **200** may proceed to operation **206** and the computing device **100** may determine whether there was also a capacitive input. In other words, the computing device **100** may determine whether there was a touch input sensed in addition to the force input. In some embodiments, the touch determination may be done simultaneously with operation **204**, as the touch information may be used (in some instances) to determine the force centroid location. In instances where the force input may be provided on the black mask **118**, or another area outside of the sensitive region of the touch interface **102**, the computing device **100** may determine that there is no capacitive input. On the contrary, if the user has provided an input to the touch sensitive area of the device **100**, such as on the touch interface **102**, the computing device **100** may detect a capacitive input (such as a change in capacitance due to a user's finger interacting with the touch sensors **130**).

[0079] If a capacitive input is not detected, the method **200** may proceed to operation **214**, which will be discussed in more detail. If a capacitive input is detected, the method **200** may proceed to operation **208** and the computing device **100**, specifically the processor **124**, may determine whether the centroid is within the boundary. For example, with reference to FIG. **5**B, the boundaries **148**, **150** may surround each of the touches and may extend around the touch location a predetermined distance.

[0080] If the centroid is not within the boundary, the method **200** may proceed to operation **210**. As discussed above with respect to FIGS. **5**A and **5**B, when the centroid is outside of the touch boundary **148**, **150**, the method **200** may proceed to operation **210** and the touch input may be rejected. For example, as shown in FIGS. **5**A and **5**B, the touch may be due to the thumb **142** and thus may be determined to be inadvertent if it is outside the boundary surrounding the touch. If the centroid is within the boundary, the method **200** may proceed to operation **208**, which will be discussed in more detail below.

[0081] With continued reference to FIG. **7**, after operation **210** and the capacitive touch is rejected or otherwise not processed, the method **200** may proceed to operation **214**. In operation **214**, the processor **124** may determine whether the centroid location corresponds to a button location and/or whether the movement corresponds to a command, such as a gesture. For example, with reference to FIG. **6**, the computing device **100** may include a number of buttons within the black mask **118** which may be determined to be selected with the force centroid has a location approximately equal to the location of the button or other predefined area.

[0082] If the centroid location does not correspond to a button location or a gesture, the method **200** may proceed to optional operation **218**. In operation **218**, the computing device **100** may store the force input information, such as the centroid location in one or more of the memory components. In these embodiments, the stored information may be used at a later time, such as if there is a subsequent touch in the touch interface **120** region that may have begun with an input force in the black mask **118**. However, in other embodiments, the force information may not be stored.

[0083] However, if the centroid location corresponds to a button or gesture, the method **200** may proceed to operation **216** and the processor **124** may process the button or gesture. This may include providing the input to an application running, or otherwise utilizing the force inputs. After operations **216** and **218**, the method **200** may proceed to an end state **224**.

[0084] As briefly discussed above, in operation **208** if the centroid is within the boundary, the method **200** may proceed to operation **212**. In operation **212** the computing device **100** may determine whether the centroid has moved. For example, in instances where a user may be performing a touch gesture, the centroid may have moved from the black mask **118** to the touch interface **102** region as the user completed the gesture. Centroid movement may be determined by analyzing one or more previous centroid locations based on one or more previous force inputs.

[0085] If the centroid has moved, the method **2000** may proceed to operation **222**. In operation **222** the processor **124** may analyze the touch inputs detected by the touch interface **102** through the touch sensors **130**, as well as the centroid and force inputs to determine the gesture, and thus process the gesture input. On the contrary, if the centroid has not moved, the method **200** may proceed to operation **220** and the processor **124** may process the touch inputs. After operations **220**, **222** and the method **200** may proceed to the end state **224**.

CONCLUSION

[0086] The foregoing description has broad application. For example, while examples disclosed herein may focus on computing devices having touch interfaces, it should be appreciated that the concepts disclosed herein may equally apply to substantially any other type of communication devices. Similarly, although the touch detection is discussed with touch screens, the devices and techniques disclosed herein are equally applicable to other types of capacitive coupling systems. Accordingly, the discussion of any embodiment is meant only to be exemplary and is not intended to suggest that the scope of the disclosure, including the claims, is limited to these examples.

What is claimed is:

1. A computing device configured detect a user input comprising:

a processor;

a touch interface in communication with the processor and configured to detect a touch signal corresponding to an object approaching or contacting a surface;

at least three force sensors in communication with the processor and configured to detect a force signal corresponding to an object exerting a force on the surface; wherein

in response to the force the processor determines a force centroid location; and

the touch signals are processed by the processor by analyzing the force centroid location.

2. The computing device of claim **1**, wherein the at least three force sensors comprise four force sensors.

3. The computing device of claim **1**, wherein the touch interface is a touch screen.

4. The computing device of claim **1**, wherein if the force centroid location is outside a predetermined boundary of a touch location detected by the touch interface, the touch signal is rejected.

5. The computing device of claim **1**, wherein if the force centroid location moves between a non-touch sensitive location to a touch sensitive location in communication with the touch interface, the touch signal is processed as a gesture.

6. The computing device of claim **1**, further comprising a cover surface operably connected to the touch interface and the at least three force sensors, wherein the at least three force sensors detect an applied force through the cover surface.

7. The computing device of claim **6**, wherein a non-touch sensitive region is defined as a portion of the cover glass that is not in communication with the touch interface.

8. The computing device of claim **7**, wherein if the force centroid location moves between the non-touch sensitive location to a touch sensitive location in communication with the touch interface, the touch signal is processed as a gesture.

9. A method for detecting user inputs to a computing device through force sensing, comprising:

detecting by three or more force sensors, a force input;

calculating by a processor in communication with the force sensors, a force centroid based on the force input; and

using the force centroid to analyze one or more user inputs to the computing device.

10. The method of claim **8**, further comprising searching for a touch input applied to the computing device, and if a touch input is detected determining if the force centroid is within a boundary surrounding the touch input.

11. The method of claim **10**, wherein if the force centroid is outside of the boundary, rejecting the touch input, and if the force centroid is within the boundary processing by the processor the touch input.

12. The method of claim **9**, further comprising determining if the force centroid corresponds to a button location, and if the force centroid corresponds to the button location providing a button input to the processor.

13. The method of claim **12**, wherein the button is a virtual button positioned outside of a touch sensitive region of the computing device.

14. A mobile computer configured to detect at least two types of user inputs comprising:

a processor;

a touch screen in communication with the processor and configured to detect a touch signal corresponding to a user finger approaching or contacting the touch screen;

at least three pressure sensors in communication with the processor and configured to detect a pressure signal corresponding to an object proving pressure on a surface, wherein

in response to the pressure signal the processor determines a centroid location relative to the surface; and

the touch signal is processed by the processor by analyzing the centroid location.

15. The mobile computer of claim **14**, wherein the processor rejects the touch signal if the centroid location is outside of a touch sensitive region of the touch screen region.

16. The mobile computer of claim **14**, further comprising

an enclosure operably connected to the touch screen and the at least three pressure sensors; and

a cover glass extending over at least a portion of the touch screen and the at least three pressure sensors.

17. The mobile computer of claim **14**, wherein the at least three pressure sensors are strain gauges.

18. The mobile computer of claim **14**, wherein the touch signal is a change in capacitance.

19. The mobile computer of claim **14**, wherein if the centroid location moves from outside of the touch screen to the touch screen, the processor processes the touch signal as a gesture.

20. The mobile computer of claim **14**, wherein the processor is further configured to determine if the centroid location corresponds to a button location, and if the force centroid corresponds to the button location providing a button input to the processor.

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